Logistics Optimization
Assignment (Due: Dec 7 2025)

Please provide detailed solutions with the methodology, results and plots in a pdf. Also provide the accompanying MATLAB/Python code for each problem.

Problem 1- Warehouse Location Optimization for an Automotive Company

An automotive company wants to optimize the location of its distribution warehouses to minimize transportation costs to its regional dealerships. The company operates in four major regions: North, South, East, and West, with demand at various dealerships in each region. The task is to determine the optimal location for two new warehouses such that the total transportation cost is minimized.

Problem Statement: Given the following data:

- o The coordinates of dealerships in the regions are provided in kilometers, with demand at each dealership in terms of units.
- o The cost of transportation is directly proportional to the distance between the warehouse and the dealership, and the objective is to minimize the total transportation cost.

The decision variables are the coordinates of the two warehouses, and the objective is to minimize the cost of transporting goods to the dealerships while satisfying the demand.

Dealership Locations and Demands:

Dealership	Region	Coordinates (x, y)	Demand (units)
D1	North	(10, 50)	200
D2	North	(20, 45)	150
D3	South	(90, 10)	180
D4	South	(85, 15)	170
D5	East	(60, 70)	160
D6	East	(65, 75)	140
D7	West	(15, 25)	130
D8	West	(20, 30)	120

Problem 2 - Logistics Optimization Problem: Fleet Scheduling for an E-commerce Company

Background:
An e-commerce company is planning to optimize its delivery fleet scheduling. The company has three distribution centers (DCs) and five delivery zones (DZs). Each DC has a fixed capacity in terms of the number of packages it can process daily, while each DZ has a fixed demand of packages to be delivered.
The company wants to optimize the number of trucks to send from each DC to the delivery zones such that the total cost is minimized. The cost is determined by the distance between the DCs and DZs, and the goal is to ensure that each delivery zone's demand is met while not exceeding the capacity of the distribution centers.

Problem Statement:

Distribution Center (DC)	Capacity (packages)
DC1	500
DC2	600
DC3	400

Delivery Zone (DZ)	Demand (packages)
DZ1	200
DZ2	300
DZ3	350
DZ4	400
DZ5	250

Cost Matrix (Cost of sending 1 package from a DC to a DZ):

From \ To	DZ1	DZ2	DZ3	DZ4	DZ5
DC1	4	3	6	8	9
DC2	5	8	3	7	6
DC3	9	4	7	5	2

Objective:
Minimize the total transportation cost while ensuring that:
1. Each delivery zone receives the required number of packages.
2. The number of packages dispatched from each distribution center does not exceed its capacity.

Problem 3 - Error Trend and Seasonality (ETS) Model

SportWear Inc. is a retail company specializing in athletic footwear. They want to forecast their monthly sales for the next year. Historical data shows clear seasonal patterns with peaks during back-to-school season (August) and holiday season (December), as well as a general upward trend over the years.

Given the following monthly sales data for the past 3 years (2021-2023) in thousands of units:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	45	42	48	52	55	58	62	75	65	60	63	80
2022	50	47	53	57	60	64	68	82	70	65	69	87
2023	56	52	58	63	66	70	74	89	76	71	75	94

Tasks

1. Identify the components present in the data (trend, seasonality, error).

2. Using an additive ETS model:
   a) Calculate the seasonal indices for each month
   b) Determine the trend component
   c) Make a forecast for January-March 2024
   d) Calculate and interpret the Mean Absolute Percentage Error (MAPE

Problem 4 - ARIMA Model

FreshFood Delivery is an online grocery delivery service that wants to forecast their daily order volumes. They have collected data for the past 180 days and noticed that order volumes show some autocorrelation, where busy days tend to be followed by other busy days.

Given: Daily order volumes for 180 consecutive days (data available upon request), with the following characteristics:

- Mean: 520 orders/day
- Standard deviation: 85 orders/day
- Significant autocorrelation at lags 1 and 7
- No clear trend
- Weekly seasonality

Tasks

1. Based on the autocorrelation and partial autocorrelation functions:
   a) Determine appropriate values for p, d, and q in the ARIMA(p,d,q) model
   b) Justify your choice of parameters

2. Using your chosen ARIMA model:
   a) Fit the model to the first 170 days of data
   b) Generate forecasts for days 171-180
   c) Compare forecasts with actual values
   d) Calculate and interpret the Root Mean Square Error (RMSE)

Data Preparation Code:

```
clear all
clc
close all

% Generating sample data similar to the problem description
rng(42); % For reproducibility
t = 1:180;
% Simulate ARIMA(1,0,1) process with weekly seasonality
phi = 0.7;  % AR parameter
theta = 0.3; % MA parameter
mu = 520;    % Mean
sigma = 85;  % Standard deviation

% Generate random innovations
e = sigma * randn(size(t));
% Add weekly seasonality
seasonal_pattern = 50 * sin(2*pi*t/7);

% Generate ARIMA process
y = zeros(size(t));
y(1) = mu + e(1);
for i = 2:length(t)
    y(i) = mu + phi*(y(i-1)-mu) + e(i) + theta*e(i-1);
end
daily_orders = y' + seasonal_pattern';
```